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METHOD OF MAKING RIGID LAMINATE OF THERMOPLASTIC SHEETS HAVING INCREASED LOAD-BEARING ABILITY

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This invention relates to laminated plastic material and to shaped articles, particularly hollow articles, produced therefrom, as well as to a method of making shaped laminated thermoplastic materials. More particularly the invention is directed to the reinforcement of laminated sheet materials by producing hollow sections between the layers in such a manner as to increase the rigidity and load-bearing ability of the laminate.

The invention will be described with reference to the accompanying drawings, wherein:

FIG. 1 is a sectional elevational view of plastic sheets preparatory to lamination;

FIG. 2 is a similar view of the plastic sheets being laminated between the platens of a press;

FIG. 3 is a plan view of the laminated sheets;

FIG. 4 is a sectional elevational view of the laminate in a mold prior to forming a hollow section in the laminate;

FIG. 5 is a view similar to FIG. 4, showing the hollow section formed in the laminate in the mold;

FIG. 6 is a plan view of the laminate with formed hollow section after removal from the mold;

FIG. 7 and FIG. 8 are views similar to FIGS. 4 and 5, respectively, showing a modification of the invention wherein hollow sections are formed in each side of the laminate;

FIGS. 9 and 10 are views similar to FIGS. 2 and 5, respectively, showing a modification of the invention in which the laminate includes expanded plastic layers;

FIG. 11 is a sectional elevational view of a modified laminate of the invention embodying a plastic piece to form a transverse reinforcing member in a hollow section of the laminate;

FIG. 12 is a plan view of the laminate of FIG. 11;

FIG. 13 is a sectional elevational view of the laminate of FIG. 11 disposed in a mold for forming hollow sections in the laminate;

FIG. 14 is a view similar to FIG. 13, showing the hollow sections formed in the laminate; and,

FIG. 15 is a plan view of the modified laminate of FIG. 14 after removal from the mold.

Shaped articles are commonly made from thermoplastic materials by forming the thermoplastic material into a sheet and thereafter subjecting the sheet to a shaping operation, such as a drawing operation, frequently by vacuum forming or with the aid of equivalent differential pressure forming. When it is desired to make rigid articles relatively rigid thermoplastic sheets can be used, but for some purposes, such as automobile or truck doors, trunk lids or hoods, boat hulls, trailer bodies, or the like, the shaped articles are still not sufficiently rigid and subsequent reinforcement has to be resorted to. Lamination of more than one layer of thermoplastic material, particularly when one of the layers is made of an expanded plastic as described in U.S. Patents 3,041,220. Martin et al., June 26, 1962, or 3,070,817, Jan. 1, 1963, makes possible increased rigidity, but for some purposes even more stiffness and load-bearing capacity are desirable. Various proposals for increasing the rigidity such as forming ribs in the plastic sheets, lamination with epoxy resin or the like in combination with fabrics (such as glass cloth, etc.), and the bonding of metal parts to the plastic sheet, are deficient in one or more of the following respects:

(1) Lack of strength.

(2) Addition of weight.

(3) Limitation of appearance of surface in finished part to that required by the added reinforcing parts.

(4) The added reinforcement requires extra operations, increasing the labor and tooling costs.

The present invention is directed to a method of reinforcing articles made from thermoplastic sheet material, which does not require any foreign reinforcing member bonded to the surface, but instead deforms the plastic sheet in a unique manner so that it is self-reinforcing. The method is suited to laminated structures comprising two or more plastic sheets.

In accordance with the invention, certain pre-selected areas of the plastic sheets, prior to lamination, are treated in such manner as to make them non-adherent to each other, for example by applying a non-adhesive parting membrane of any suitable kind (e.g. a piece of paper, or a layer of talc). The plastic sheets are then laminated together, for example by superimposing the sheets and applying heat and pressure whereby the contacting faces of the sheets become adhered together except at the pre-selected localized areas or islands where the parting membrane prevents adhesion.

Provision is made for access of air or other suitable fluid into the interior of the laminate at the area of the parting membrane. Thus, before the laminating operation there may be deposited between the sheets a bleeder member (such as a small tube or hose, or an air-wicking cord or the like or even a strip of the parting membrane) extending from the area of the parting membrane to an outer edge of the sheet. The parting membrane and bleeder member thus become sandwiched in between the sheets in a laminating operation; the area covered by the parting membrane is surrounded by and sealed off by the contacting, adhered areas of the laminated sheets, except for the opening or passageway represented by the bleeder means. Alternatively, instead of depositing a bleeder member between the sheets prior to the lamination, a hollow needle or the like may be injected into the area occupied by the parting membrane, subsequent to the lamination.

To make the laminate exceedingly rigid in accordance with the invention the laminate is heated to a temperature at which the plastic sheet material is readily shapable by application of differential pressure, and while the laminate is in this heated condition differential pressure is applied to the laminate, for example by applying vacuum to one or both of the outside surfaces of the laminate and/or by applying air or similar fluid under pressure to the bleeder member where it projects at the edge of the laminate, or to a hollow needle inserted as described. As a result of such application of differential shaping pressure, the areas in contact with the parting member are deformed away from each other forming a kind of internal bubble or hollow section. The size of the internal bubble may be controlled by regulating the pressure, particularly where a precisely shaped bulge is not required, but in those cases where more precise control of the dimensions of the expanded section is required, resort may be had to a properly placed rigid external confining means. Thus, the outward expansion can be controlled to provide the desired shape and cross-sectional dimension by means of a rigid form or mold of any suitable kind. It will be understood that the areas of the contacting faces of the laminated sheets which were not covered by the parting member remain adhered together during this operation. It will also be understood that when such formation of a hollow section between the